Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	)	
	)	
Facilitating Opportunities for Flexible, Efficient, And Reliable Spectrum Use Employing Cognitive Radio Technologies	)	ET Docket No. 03-108
	)	
Authorization and Use of Software Defined Radios	)	ET Docket No. 00-47 (Terminated)

COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

Michael D. Gallagher
Assistant Secretary for
Communications and Information

Kathy D. Smith
Chief Counsel

Fredrick R. Wentland
Associate Administrator
Office of Spectrum Management

Edward Drocella
Mark Settle
Electronics Engineers

Office of Spectrum Management

National Telecommunications and
Information Administration
U.S. Department of Commerce
Room 4713
1401 Constitution Avenue, N.W.
Washington, DC 20230
(202) 482-1816

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The National Telecommunications and Information Administration (NTIA) commends the Federal Communications Commission (Commission) for initiating this proceeding to examine issues related to the development and deployment of cognitive radio (CR) technology. NTIA believes that CR technology has the potential to provide more innovative, flexible, and comprehensive use of the radio frequency spectrum, while at the same time minimizing the risk of interference to other spectrum users. CRs can be developed that have the technical capability to adapt their use of the spectrum in response to information external to the radio. As a result of this technical and operational flexibility, CR technologies may also make it possible to use spectrum that may be available in a particular geographic location or during a particular period of time and would otherwise go unused. At this time, there is not a clear boundary between CR and software defined radio (SDR) technologies. In many instances, SDR will be used as the basic platform on which to build CR technology. For this reason, the comments will in certain cases address SDR issues as well as CR, since certain aspects of the SDR regulatory framework could influence the transition from SDR to CR. NTIA offers the following comments in response to the specific issues raised by the Commission in the Notice of Proposed Rulemaking (NPRM).

There is little information given in the NPRM on what CR technologies and techniques are viable today, or in the near future, and what techniques or technologies may only be achievable with advances in technology. NTIA believes that given the relative maturity of the sensing and geo-location techniques proposed in the NPRM, employing them to facilitate sharing in the restricted frequency bands is not practical. Therefore, NTIA agrees with the Commission's tentative conclusion that unlicensed devices employing CR techniques should be

prohibited from operating in the restricted frequency bands listed in Section 15.205 of the Commission's Rules.

NTIA analysis indicates that when the transmit bandwidth of the unlicensed device is greater than 6 MHz, the power levels and detection threshold proposed by the Commission are adequate to protect government radar systems operating in the 5725-5875 MHz band. For transmit bandwidths less than 6 MHz, NTIA analysis indicates that the power levels of the unlicensed device would have to be reduced below the level proposed by the Commission to protect these government radar systems. Since there were many technical parameters that were not included in the Commission's proposal, NTIA considers this a preliminary assessment of the potential interference to government radar systems operating in the 5725-5875 MHz band. If service rules are eventually adopted for higher-powered unlicensed devices operating in the 5725-5875 MHz band that are significantly different than those considered in the assessment in Appendix A, NTIA would have to reassess the sharing situation.

When the level of unwanted emissions are independent of the in-channel power, NTIA recommends that the limits specified in Sections 15.247 and 15.249 of the Commission's Rules be applied for the higher-powered unlicensed devices as proposed by the Commission. For higher-powered unlicensed devices where the unwanted emissions are dependent on the in-channel power level, the unwanted emission limit should be reduced commensurate with the increase in the in-channel power level.

NTIA believes that geo-location technology used in conjunction with an on-line database of sites that require protection holds promise for facilitating sharing between unlicensed devices and radio services using receivers at fixed locations. However, there are many issues related to the accuracy and integrity of the on-line database as well as the integrity of the data downloaded

to the unlicensed device that must be addressed.

The lack of interoperability is the most significant problem contained in after action reports from major public safety incidents. Arguably, SDR and eventually CR promise to be the best long-term interoperability solution. The Commission's Rules are not limiting the use of SDR to facilitate the interoperability between public safety systems. However, there still remain technical, legal, and cost issues that need to be resolved before the full benefits of SDR can be realized as a solution for public safety interoperability.

Mesh networks allow nodes or access points to communicate with other nodes without being routed through a central switch point, eliminating centralized failure, and providing self-healing and self-organization. NTIA believes that the short range characteristics of mesh networks lend themselves to using higher frequencies. NTIA also believes that mesh networks have the capability to increase capacity as the number of nodes increases, enabling them to deliver broadband data rates to support high-speed data, video and voice applications.

Geo-encryption is an approach to location-based encryption that builds on established cryptographic algorithms and protocols. Geo-encryption techniques can support both fixed and mobile applications and a variety of data-sharing and distribution policies. NTIA believes that geo-encryption techniques can be used in conjunction with existing encryption techniques to provide protection of over-the-air software downloads and should be considered in future rulemakings on CR and SDR technologies.

If the Commission contemplates expanding the implementation of higher-powered unlicensed device operations employing CR techniques, NTIA recommends that the frequency bands transferred from federal government to private sector use be considered, because, at this time, these bands have limited government or commercial use or have not been transferred for

private sector use.

NTIA supports the actions taken by the Commission to remove regulatory barriers to the development of secondary markets. These flexible policies will continue the evolution toward greater reliance on the marketplace to expand the scope of available wireless services. Because CRs can play an enabling role in the establishment of secondary markets, the development of CR technology should also have similar, minimum regulatory constraints.

There is no reason to regulate component parts such as digital-to-analog converter (DAC) integrated circuits and the Commission should avoid any regulation that would likely stifle their use. A DAC add-in card alone does not possess the capability to act as a transmitter, and thus should not be subject to regulation as a radio transmitter under the Commission's Rules. If a DAC is coupled with an amplifier and antenna, it should be considered a SDR or CR and regulated under the applicable section of the Commission's Rules. NTIA also recommends that as potential consumer applications of DAC based radio frequency signal sources become better understood, the Commission consider revisiting its regulation.

NTIA is concerned about the regulatory implications associated with downloaded software that can reconfigure the radio functionality, which includes frequency, power, and modulation. NTIA understands the Commission's reluctance to adopt specific security requirements because this may constrain the development SDR technology. However, NTIA believes that the acceptance of SDR and eventually CR technologies hinges on assurances that the operating parameters that can impact electromagnetic compatibility with other systems are protected from malicious attacks. NTIA recommends that as a long-term goal of addressing security concerns for devices that employ SDR and CR technologies, the Commission should consider requiring Protection Profiles as part of the equipment certification.

NTIA agrees with the Commission that examination of software is not an effective means of identifying where unauthorized software changes have been made in an SDR. NTIA believes that the Commission's requirement that certified devices must comply with their applicable technical rules is sufficient to safeguard against unauthorized equipment modifications. Thus, NTIA agrees with the Commission's proposal to eliminate the existing requirement for applicants to provide copies of their software as part of the certification process for SDRs.

NTIA believes that it would be appropriate for the Commission to require manufacturers to declare their devices as SDRs if the device is remotely programmable and has hardware that is capable of transmitting in the restricted frequency bands or in frequency bands allocated to the federal government on an exclusive basis. This would eliminate the problems associated with incorrectly classifying commercial devices such as land mobile radio and personal communication service as SDRs.

CR devices that are capable of changing their electromagnetic characteristics on a near real-time basis will make the compliance measurements more complex. NTIA believes that technological approaches that cannot be verified in the Telecommunication Certification Bodies' laboratories should not be relied upon for successful spectrum sharing. NTIA recommends that the Commission resolve all of the technical issues related to performing the compliance measurements prior to implementing CR techniques in any frequency band. NTIA further recommends that the compliance measurement procedures for devices employing CR technologies be developed in an open forum, and government and non-government parties should participate.

NTIA recommends that a new subpart within Part 15 of the Commission's Rules be established for unlicensed devices that employ CR techniques. This is similar to the approach

used for unlicensed UWB devices, which also did not fit into the existing Part 15 Rules. NTIA also recommends that the Commission adopt a definition for CR in order to provide regulatory certainty to manufacturers seeking industry investment in devices based on these new technologies.

If the Commission adopts its proposal to certify unlicensed devices that are capable of using non-Part 15 frequencies then it should limit this to devices where the central controllers can control the transmit frequencies of the client devices. As part of the device certification process it is imperative that it be ensured that the central controllers can only operate in the bands authorized for Part 15 operations. For unlicensed devices that operate without a central controller, the device should be required to incorporate geo-location capabilities, such as the Global Positioning System, in conjunction with a database, to determine its geographic location. The location information would then be used to control the authorized frequencies that the unlicensed device can use. Furthermore, if the unlicensed device is not capable of determining its geographic location, the device must be restricted from transmitting.

NTIA agrees with the Commission regarding the significant benefits that could be gained by employing CR technologies. The NPRM identifies several areas where technical and regulatory issues must be addressed. NTIA supports the Commission's initial implementation approach, limiting CR technologies to a few frequency bands primarily used by unlicensed devices. NTIA believes that the experience gained in these frequency bands will help facilitate a much broader implementation of CR technologies while ensuring that government and non-government spectrum users are adequately protected from interference. NTIA will continue to work with the Commission and industry to resolve the technical and regulatory issues surrounding the successful implementation of CR technologies.

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COMMENTS OF THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

The National Telecommunications and Information Administration (NTIA), an Executive Branch agency within the Department of Commerce, is the President's principal adviser on domestic and international telecommunications policy, including policies relating to the Nation's economic and technological advancement in telecommunications. Accordingly, NTIA makes recommendations regarding telecommunications policies and presents Executive Branch views on telecommunications matters to the Congress, the Federal Communications Commission (Commission), and the public. NTIA, through the Office of Spectrum Management (OSM), is also responsible for managing the federal government's use of the radio frequency spectrum. NTIA respectfully submits the following comments in response to the Commission's Notice of Proposed Rulemaking (NPRM) in the above-captioned proceeding.[1]

1. *Facilitating Opportunities for Flexible, Efficient, and Reliable Spectrum Use Employing Cognitive Radio Technologies*, Notice of Proposed Rulemaking, ET Docket No. 03-108, 18 F.C.C. Rcd. 26859 (2003) ("Cognitive Radio NPRM").

I. INTRODUCTION

In the NPRM, the Commission seeks comments on ways to encourage and remove regulatory impediments to the continued development and deployment of cognitive radio (CR) technologies. For example, facilitating the ability of licensed spectrum users to deploy CR for their own use to increase spectrum efficiency, and to facilitate secondary markets, allowing licensees to lease their spectrum access to third parties using such technologies. The Commission seeks comment on ways in which CR can facilitate opportunistic use of the spectrum by unlicensed devices, while protecting incumbent licensed spectrum users from interference; rules permitting additional flexibility, including allowing unlicensed devices, in limited frequency bands to use higher transmit power in rural and underserved areas; a specific technical approach that would provide licensees, such as public safety entities, with the ability to retain real-time access to spectrum they lease to third parties; how CR can enhance the ability of different public safety entities using different frequencies and formats to communicate with one another in the event of an emergency; and specific applications of CR, such as mesh networks and real-time frequency coordination between non-geostationary orbit satellite systems and other services. The Commission also proposes changes to its equipment authorization processes to better accommodate software defined radio (SDR) and CR systems.

At this time, there is not a clear boundary between CR and SDR technologies. In many instances, SDR will be used as the basic platform on which to build CR technology. For this reason, NTIA's comments will in certain cases address SDR issues as well as CR, since certain aspects of the SDR regulatory framework could influence the transition from SDR to CR. For example, SDR could support interoperability by providing the capability where the user selects the required radio configuration based on knowledge of the users and communication content for

a given region. This SDR could evolve into a CR that senses the radio frequency (RF) environment and automatically selects the desired radio configuration or might even have the capability to recognize that another band is not being used in the area of interest and thus could direct certain users in a congested band to this alternative frequency band.

NTIA commends the Commission for initiating this proceeding to examine issues related to the development and deployment of CR technology. NTIA believes that CR technology has the potential to provide more innovative, flexible, and comprehensive use of the RF spectrum, while at the same time minimizing the risk of interference to other spectrum users. However, there are technical and regulatory issues related to implementing CR as well as concerns regarding potential interference to federal spectrum users that must first be addressed. NTIA offers the following comments in response to the specific issues raised by the Commission in the NPRM.

II. COGNITIVE RADIO CAPABILITIES CAN BE USED TO RESOLVE SPECTRUM SCARCITY, DEPLOYMENT, AND TECHNOLOGY TRANSITION PROBLEMS ENCOUNTERED BY GOVERNMENT AND NON-GOVERNMENT WIRELESS SYSTEMS.

There are a number of capabilities, such as frequency agility, adaptive modulation, transmitter power control (TPC), location of itself and other transmitters, and mechanisms to enable sharing on an ad-hoc or real-time basis, that can be incorporated in CRs. The Commission seeks comment on what other features and capabilities a CR could incorporate.[2]

There are several problems confronting both government and non-government wireless communications users with respect to spectrum use: scarcity of spectrum, deployment difficulties, and transitioning to different technologies. The federal government agencies are

2. Cognitive Radio NPRM at ¶ 22.

placing an increasing emphasis on SDR and using SDR as the basic platform on which to build CR technology to resolve these problems. For example, through research projects such as the Defense Advanced Research Projects Agency (DARPA) neXt Generation (XG) program, the Department of Defense (DOD) is investigating how advanced sensing, modulation, and multiple access technologies can be used with a machine-intelligible spectrum policy framework to enable cognitive spectrum sharing that could improve spectrum usage efficiency by a factor of ten or more.[3] As the Commission points out, SDRs are likely to be the best platforms for implementing CR, and the tactical military SDRs being developed under the Joint Tactical Radio System (JTRS) may well be the beneficiaries of the XG technology. The application of XG technology to JTRS has the potential to address the spectrum scarcity and deployment issues that could limit the military's broadband wireless end-to-end connectivity. Like DARPA's early work on the Internet, XG-based technology will become applicable to both military and civilian applications. The National Science Foundation (NSF) is also exploring the technology developments needed for enhancing spectral efficiencies of wireless networks in support of expanding opportunities for new services in the wireless industry. NSF's Networking Technology Systems (NeTS) program is addressing the challenges associated with these networks.[4]

Over the years, the development of better electronic equipment has allowed the channel spacing employed by many radio services to be decreased. For example, many radio services have changed channel spacing from 100 kHz to 50 kHz, then to 25 kHz, and now radio services

3. XG Working Group, *The XG Vision*, Request for Comments, Version 2.0, BBN Technologies, Cambridge Massachusetts. This document and other information about the DARPA XG program are available at http://www.darpa.mil/ato/prgrams/XG/rfcs.htm.

4. National Science Foundation, Directorate for Computer and Information Science Engineering, Division of Computer and Network Systems, Research in Networking Technology and Systems (NeTS). More information on the NeTS program is available at http://www.cise.nsf.

are instituting even narrower channels (e.g., 12.5 kHz and 6.25 kHz in some land mobile frequency bands). Because of the need for backward compatibility, however, most of the radio services cannot take full, immediate advantage of the increased spectrum use of narrower channels. For example, legacy equipment does not have the capability to tune to the interstitial channels. Moreover, transition of these services from analog to digital modulation techniques, which can support a more flexible and efficient use of the spectrum, has been difficult because of the backward compatibility requirement. CRs could facilitate this transition in channelization and modulation schemes. By being able to switch modulation/detection schemes, to switch frequencies and bandwidths of operation, and possibly, to sense the characteristics of received signals and to institute actions based on these characteristics, CR could operate in this transitional environment. Since the particular service in question is largely under the control of a single user group or entity, the transition can be planned and implemented in an orderly fashion, possibly segmenting the band for different operations to provide support for newer equipment (new channelization and modulation) as well as legacy systems (old channelization and modulation). This band segmentation would gradually be phased-out, however, during and after the transition, the CR would be capable of operating across the band. Because of the planned transition of the band, the CR requirements would be fairly well defined. For example, the Federal Aviation Administration's Next-Generation Air/Ground Radio Communications System (NEXCOM) will be employing some of these techniques to meet the growing need for voice services while also providing a robust data link.[5]

The federal government is developing CR technologies that are able to sense, characterize, identify, distribute, and allocate spectrum use opportunities. These CR capabilities

5. Federal Aviation Administration, *Radio Spectrum Plan*, at Section 1.7 (January 26, 2004).

may eventually be used to resolve the spectrum scarcity and deployment problems encountered by government and non-government wireless systems. CR capabilities can also be used to resolve problems encountered when transitioning from one technology or another within a frequency band or radio service.

III. HIGHER-POWERED UNLICENSED DEVICES EMPLOYING COGNITIVE RADIO TECHNIQUES SHOULD BE PROHIBITED FROM OPERATING IN THE RESTRICTED FREQUENCY BANDS LISTED IN SECTION 15.205 OF THE COMMISSION'S RULES.

The Commission concluded that it should continue to prohibit unlicensed devices from emitting in the designated restricted frequency bands, which includes many bands used by the federal government. The Commission seeks comment on this tentative conclusion.[6]

The restricted frequency bands in Section 15.205 of the Commission's Rules are used to support safety-of-life functions, such as aeronautical radionavigation, military satellite communications, and scientific observations. The federal systems that operate in the restricted frequency bands may be passive, such as radio astronomy, or active, such as satellite downlinks. The NPRM focuses on two types of CR techniques: sensing techniques and geo-location techniques. However, NTIA believes that there are potential problems with effectively implementing either of these CR techniques in the restricted frequency bands.

For CR sensing techniques to be effective in facilitating sharing with other radio services, it must be able to detect a signal that is above a specified threshold. The presence of a signal above the detection threshold indicates that the channel is being used and the CR-enabled device should not transmit. If the signal is below the threshold or the sensitivity of the sensor receiver is not adequate to detect the signal, the CR-enabled device will transmit and potentially cause

6. Cognitive Radio NPRM at ¶ 31.

interference to other receivers operating in the band. It is difficult to envision how CR sensing techniques can be implemented in many of the restricted frequency bands since the detection thresholds would have to be much lower than can be supported by current technology. For example, due to the extremely low power of the cosmic signals studied by the radio astronomy and passive services, these operations are very susceptible to interference. The permissible interference levels in several radio astronomy frequency bands are shown in Table 1.[7]

Table 1.

Frequency Range (MHz)	Permissible Interference Level (dBW)
608-614	-202
1400-1427	-205
4990-5000	-207

These permissible interference levels would be used as the basis for establishing the detection thresholds for CR sensing techniques, and are believed to be outside the range of any practical sensing techniques currently available. Therefore, NTIA does not believe that CR sensing techniques can be implemented in the restricted frequency bands used by the radio astronomy and passive services.

Implementing CR sensing techniques in the restricted frequency bands used to support receive-only operations would face problems similar to those identified for the passive services. This would apply to frequency bands used by military satellite downlink communications or the radionavigation satellite service (RNSS), which are capable of receiving very weak desired signals. For example, the Global Positioning System (GPS), which operates in the frequency bands allocated for RNSS, employs direct sequence spread spectrum (DSSS) and receivers are

7. Recommendation ITU-R RA.769-1, *Protection Criteria Used for Radioastronomical Measurements* (1992-1995).

capable of processing desired signal levels below the noise floor. For an unlicensed device employing CR sensing techniques to protect RNSS receivers the detection threshold would have to be below the thermal noise floor, which NTIA does not believe is feasible using existing technology.[8]

CR sensing techniques would also be difficult to effectively implement in any of the restricted frequency bands where the receivers are mobile and transmissions are non-continuous. This situation occurs in the restricted frequency bands used by the aeronautical radionavigation service (ARNS). In the ARNS, ground-based stations are transmitting and receiving information from aircraft that can be located anywhere. The desired signals at the airborne receiver can vary significantly, making sensing techniques that protect these critical safety-of-life functions difficult to implement. Further complicating the problem is that the transmissions from the ground stations are non-continuous, and it would be very difficult, if not impossible, for CR sensing techniques to predict with any degree of certainty when the primary user activity be initiated or resume on the channel.

When the locations of the licensed systems are known and fixed, CR geo-location techniques hold promise for facilitating sharing with unlicensed devices. However, many designated restricted frequency bands are used for military satellite communications and the locations of these receivers cannot be identified. There are also many restricted frequency bands that are used by mobile receivers, such as those in the ARNS and RNSS. NTIA believes that CR geo-location techniques would not be effective in protecting the critical safety-of-life operations

8. In the NPRM, the Commission describes cyclostationary detectors or feature detectors, which use longer sensing times and internal computation to achieve signal sensitivities below the noise level for signals of known format. Cognitive Radio NPRM at ¶ 25. However, the practical capabilities and limitations of these detectors need to be studied and demonstrated to determine whether or not they can contribute significantly to the implementation of CR sensing techniques.

in these frequency bands. The Commission needs to resolve questions regarding accessing an on-line database on a near real-time basis, the integrity of the data downloading process, and how the database is maintained.

The NPRM provides little information on what technologies and techniques are viable today, or in the near future, and what techniques or technologies may only be achievable with potential advances in technology in the future. NTIA believes that given the relative maturity of the sensing and geo-location techniques proposed in the NPRM, employing them to facilitate sharing in the restricted frequency bands is not practical. Therefore, NTIA agrees with the Commission's tentative conclusion that unlicensed devices employing CR techniques should be prohibited from operating in the restricted frequency bands listed in Section 15.205 of the Commission's Rules.

IV. THE COMMISSION'S PROPOSAL FOR HIGHER-POWERED UNLICENSED DEVICE OPERATIONS IN THE 5725-5875 MHz BAND IS ADEQUATE TO PROTECT GOVERNMENT RADAR SYSTEMS IF A MINIMUM TRANSMIT BANDWIDTH IS ESTABLISHED.

The Commission proposes to allow a transmitter power increase of up to six times the current limits in the frequency bands specified in Sections 15.247 and 15.249 of its Rules.[9] The Commission proposes to restrict the higher power operation to areas with limited spectrum use and to require the unlicensed devices to sense spectrum use before commencing transmission.[10] The Commission seeks comment on the potential effects of this proposal, including its CR safeguards of federal radio operations in the 5725-5925 MHz band.[11]

9. Cognitive Radio NPRM at ¶ 38.

10. *Id.* at ¶ 39.

11. *Id.* at ¶ 43.

Federal government users in the 5725-5875 MHz band include fixed, transportable, and mobile radar systems operated by the DOD. These radars are used extensively in support of national and military test range operations in the tracking and control of manned and unmanned airborne vehicles.[12] As pointed out in the NPRM, many of the installations where these radar systems operate are located in rural areas to avoid interference with other systems.[13] Federal agencies are increasingly concerned regarding potential interference to these radar systems as their role expands in support of homeland defense. This expanded role could result in a requirement to deploy radar systems in areas close to cities and highways, potentially increasing interference to the radar systems from unlicensed devices operating at higher power levels.

Under the Commission's proposal, the higher-powered unlicensed device operations would be limited to rural areas or areas where it is determined that spectrum use is limited.[14] The Commission proposed that the unlicensed devices operating in these rural or unused areas employ sensing techniques with a detection threshold of 30 dB above the thermal noise floor within a measurement bandwidth of 1.25 MHz.[15] The potential interference between military radar systems operating in the 5250-5350 MHz and 5470-5725 MHz bands and Unlicensed National Information Infrastructure (U-NII) devices employing a sensing technique referred to as dynamic frequency selection (DFS)[16] was addressed as part of another rulemaking proceeding.[17]

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12. The frequency bands from 5250-5925 MHz are allocated on a primary basis to Government radiolocation.

13. Cognitive Radio NPRM at ¶ 43.

14. *Id.* at ¶ 44.

15. *Id.*

16. DFS is a mechanism that dynamically detects signals from other systems and avoids co-channel operation with these systems.

17. *Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Report and Order, ET Docket No. 03-122, 18 F.C.C. Rcd. 24484 (2003) ("U-

The analysis performed to develop the detection thresholds for DFS equipped U-NII devices considered specific unlicensed device densities and power levels that are different than those proposed by the Commission in the NPRM. Therefore, NTIA must perform an analysis to assess whether the power levels in conjunction with the detection threshold proposed by the Commission are adequate to protect government radar systems operating in the 5725-5875 MHz band.

In the NPRM, the Commission proposed a transmitter power level of 38 dBm in the 5725-5850 MHz band and 6 dBm in the 5725-5875 MHz band to be used in conjunction with the DFS sensing technique.[18] As discussed earlier, the Commission also proposed a detection threshold of -83 dBm measured in a 1.25 MHz bandwidth.[19] However, the proposal in the NPRM did not identify the unlicensed device application which could have an impact on the device density and antenna heights, the transmit bandwidth of the unlicensed device application (e.g., narrowband or wideband), or the type of antenna (e.g., omnidirectional or directional). All of these parameters can have an impact on the electromagnetic compatibility of the proposed unlicensed devices and the government radar systems.

To assess the potential interference to government radar systems from the unlicensed devices using the higher power levels and the detection threshold proposed by the Commission, NTIA performed an analysis. The analysis provided in Appendix A describes the operational

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18. Cognitive Radio NPRM at ¶ 38. A power level of 6 watts is proposed in the 5725-5850 MHz band and 125 millivolts per meter at a distance of 3 meters in the 5725-5875 MHz band.

19. *Id.* at ¶ 44. The detection threshold is specified as 30 dB above the calculated thermal noise floor within a measurement bandwidth of 1.25 MHz. The thermal noise floor of a 1.25 MHz bandwidth receiver is -113 dBm. The detection threshold proposed by the Commission is 30 dB above -113 dBm or -83 dBm.

scenario for the unlicensed devices and the military radar systems; technical characteristics of the radar systems and unlicensed devices; and the engineering algorithms used to assess the potential for interference to the radar systems from the higher-powered DFS-equipped unlicensed devices. The parametric analysis performed to assess the potential interference to government radar systems considered different combinations of the number of unlicensed devices, unlicensed device antenna heights, and unlicensed device transmit bandwidths. Monte Carlo techniques were employed for the unlicensed device locations, propagation losses, antenna heights, and other non-terrain specific losses.[20]

The analysis indicates that when the transmit bandwidth of the unlicensed device is greater than 6 MHz, the power levels and detection threshold proposed by the Commission are adequate to protect government radar systems operating in the 5725-5875 MHz band. For transmit bandwidths less than 6 MHz, the power levels of the unlicensed device would have to be reduced below the level proposed by the Commission to protect these government radar systems. Since there were many technical parameters that were not included in the Commission's proposal, NTIA's analysis is a preliminary assessment of the potential interference to government radar systems operating in the 5725-5875 MHz band. To support 5725-5875 MHz band service rules for unlicensed devices significantly different than those considered in the assessment in Appendix A, NTIA would have to re-evaluate the sharing situation.

In addition to the detection threshold, the following parameters associated with the CR sensing technique must be defined: channel availability check time, channel move time, non-

20. The Monte Carlo method has been used for the simulation of random processes and is based upon the principle of taking samples of random variables from their assumed probability density functions.

occupancy period, detector function (peak or average), and measurement interval.[21] Since the radar systems operating in the 5725-5875 MHz band are the same as those operating in the 5250-5350 MHz and 5470-5725 MHz U-NII frequency bands, then the values of the radar parameters associated with the detection threshold would be the same.[22] The Commission specifies a measurement bandwidth of 1.25 MHz, which is consistent with the channel width of code division multiple access PCS systems. To be consistent with the measurements for the radars operating in other portions of the 5 GHz band where DFS is being implemented, NTIA recommends that a measurement bandwidth for the detection level of 1 MHz be used instead of 1.25 MHz.

V. THE REDUCTION OF UNWANTED EMISSIONS FOR HIGHER POWER UNLICENSED DEVICES SHOULD BE COMMENSURATE WITH THE INCREASED IN-CHANNEL POWER LEVEL.

The Commission proposes that unlicensed devices operating at the higher power levels comply with the same harmonic and out-of-band emission limits as devices operating under Sections 15.247 and 15.249 of its Rules.[23] The Commission seeks comment on whether the out-of-band emission limits for equipment operating at the higher power levels should be adjusted so that they are no greater than those permitted under the current rules.[24]

The emissions generated by a device can be divided into three categories: necessary emissions generated within the channel of the device (in-channel); out-of-band emissions generated as a result of the modulation process; and spurious emissions such as harmonically

21. For DFS-equipped U-NII devices, these parameters are defined in Section 15.403 of the Commission's Rules.

22. The values for the DFS detection threshold and the additional parameters are provided in Section 15.407(h)(2) of the Commission's Rules.

23. Cognitive Radio NPRM at ¶ 42.

24. *Id.*

generated emissions. The combination of out-of-band and spurious emissions are referred to as unwanted emissions.

The current harmonic emission limits for unlicensed devices operating under Section 15.249 are independent of the in-channel power, while the out-of-band emission limits are a function of the in-channel power. For devices operating under Section 15.247 of the Commission's Rules, the limits on out-of-band emissions that fall within the designated restricted frequency bands are independent of the in-channel power levels. However, under Section 15.247, the limit on out-of-band emissions that fall outside of the restricted frequency bands are a function of the in-channel power level.

As shown in Appendix B, the unwanted emission limits specified in Part 15 of the Commission's Rules are inadequate to protect other authorized radio services unless either a large distance separation or additional attenuation resulting from buildings or terrain are included in the analysis. However, given the large number of Part 15 devices in use today, NTIA is unaware of any reports where a compliant unlicensed device has interfered with another authorized spectrum user. NTIA believes that in part this can be attributed to Part 15 devices generating unwanted emission levels that are well below those specified in the Commission's Rules.[25] NTIA has limited data to support this presumption, and thus, cannot comment on whether the actual unwanted emission levels specified in Sections 15.247 and 15.249 of the Commission's Rules adequately protect other radio services.

The harmonic and out-of-band emission limits specified in Sections 15.247 and 15.249 fall into two categories: limits that are dependent on the in-channel power levels, and limits that

25. The power levels of the spurious emissions in many cases are statistical in nature, where the peak levels can vary with time and frequency. Harmonic emissions are more difficult to eliminate, but at non-harmonically related frequencies the levels are also believed to be well below the limits specified in the Commission's Rules.

are independent of the in-channel power levels. For harmonic and unwanted emissions that are independent of the in-channel power (e.g., a fixed field strength level), NTIA recommends that the limits specified in Sections 15.247 and 15.249 be applied for the higher-powered unlicensed devices as proposed by the Commission. For higher-powered unlicensed devices where the unwanted emissions are dependent on the in-channel power level, the unwanted emission limit should be reduced commensurate with the increase in the in-channel power level. In the Commission's proposal, this would result in a reduction of 8 dB in the unwanted emission levels for the higher-powered devices.

VI. GEO-LOCATION TECHNOLOGIES USED IN CONJUNCTION WITH AN ON-LINE DATABASE HOLDS PROMISE FOR SHARING BETWEEN UNLICENSED DEVICES AND RADIO SERVICES USING RECEIVERS AT FIXED LOCATIONS.

The Commission seeks comment on the positional accuracy necessary if geo-location technology such as the Global Positioning System (GPS) were used. Related to CR geo-location techniques, the Commission also requests comment on how a device using geo-location would access a table or database showing where operation is permitted; who would be responsible for maintaining the database; should the geo-location technology be required to be incorporated within the device; and how would the device react if it were unable to determine its position within a specified accuracy limit.[26]

The positional accuracy of different GPS receiver architectures is discussed in Appendix C. The Commission adopted accuracy and reliability requirements for Automatic Location Identification as part of its Rules for wireless carrier enhanced 911 (E911) service.[27] The

26. Cognitive Radio NPRM at ¶ 47.

27. *Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems*, Third Report and Order, CC Docket No. 94-102, 14 F.C.C. Rcd. 17388 (1999).